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THE COSMIC SYSTEM "ELECTRON",

NEW ACHIEVEMENTS OF SOVIET SCIENCE

IN MASTERING THE COSMOS

12

By

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THE COSMIC SYSTEM "ELECTRON"

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15 March 1964

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YU.L. Logacher

SUMMARY

More than one month has passed since the launching of scientific space stations "Electron I and Electron II". Their main object is the simultaneous study of Earth's radiation belts.

This column refers specifically to the study of their orbits and of the meaning of the apparatus installed on board.

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* *

I. RADIATION BELTS

N.B. - Since we previously reported a press conference dealing with the subject (ST-PR 10 112), the first part of the present column, which deals with radiation belts, has been deleted.

II: THE ORBITS OF SPUTNIKS "ELECTRON I AND II"

The orbits for the Cosmic Stations Electron I and Electron II were chosen with the purpose of simultaneous study of the upper layers

of the atmosphere, the Earth's radiation belts and the circumterrestrial space.) At the same time several other factors have been taken into consideration, when selecting satellite orbits, such as for example the conditions providing the best radio communication during contact with the satellite, the stations' life in orbit, there illimination by the Sun, etc.

With all the above-mentioned facts in mind two elliptic orbits of great eccentricity have finally been chosen. This type of orbit provides the opportunity for scientific research at various altitudes (from the upper atmosphere layers to the interplanetary space, beyond the radiation belts). The first orbit lies in the most interesting area of the inner radiation belt; it partially intersects the outer radiation belt and then encompasses the region with the irregular magnetic field, where the unsteady charged particle flows are located. These particles are creating polar aurorae. The second orbit, partially crossing the inner belt passes through the most interesting areas of the outer belt and crosses the area with nonstationary currents of low-energy electrons, situated beyond the outer belt and designated in the scientific literature as the outermost belt of charged particles. The highest point of the first orbit, the apogee is at 7000 km, which corresponds to about the outer boundary of the inner belt, while the apogee of second orbit is in the 65000 - 70000 km range. The perigee of both orbits is established in the 400 - 460 km range.

The focal axes of spaceships' orbits have different directions. The focal asis of the low orbit passes through the inner belt. As to

that of the high orbit, it was so selected to obtain the greatest possible altitude difference at indentical grographic latitudes during flights over the ascending and descending orbits, which is important from the standpoint of scientific measurements when investigating the outer belt. The inclination selected for both orbits is about 61° to the equatorial plane. With such an inclination the orbit apogee will shift toward the north and the Electron I orbit will pass in the course of a year through the whole thickness of the inner radiation belt. The magnetude of the inclination exerts a strong effect upon orbit parameter variations under the influence of lunar and solar perturbations. The disposition of orbit perigees in the northern hemisphere assures the most favorable conditions for radio communication with the ground stations. At the same time when the stations are in the perigee region of orbits, the volume of scientific observations is maximum, inasmuch as in this region studies of upper atmosphere layers are conducted alongside with those of radiation belts. It is well known that satellites, moving along low orbits, have limited lifetime because of deceleration in the lower layers of the atmosphere. Lifetime increases with the orbit height. While these factors have little importance for the perigee of Electron satellites, the orbit increases at apogee to several tens of thousand km, involves the effect of new factors - the gravitational forces of the Moon and of the Sun. Computations have shown that under an unfavorable combination of these forces, the satellite lifetime at 65 to 70000 km may constitute several days.

In connection with that, detailed investigations were conducted

in orbits with high apogee and launching times were determined so as to assure a sufficiently long lifetime for "Electron II" over the particularly stretched orbit selected for it.

The most appropriate means of creating a cosmic system with the above mentioned orbits is the simultaneous putting in orbit of two spacecrafts by a single carrier rocket.

The availability in the Soviet Union of powerful boosters allowed this problem to be solved precisely by the above method. However, in practice this entailed serious technical problems. To that effect if was necessary to materialize the separation of the first of them over the active portion of the flight of the last stage of the carrier rocket while its engine was still operating. The separation of Electron I must have been made in such a fashion that no perturbing moments were created which would affect the guidance system of the last stage and the accuracy of rightly putting Electron II into orbit. In fact, at Electron I separation, the latter should not hit the active zone of the reactive jet of last stage's engine.

Both these difficulties were overcome by using a special reactive system ensuring the separation of Electron I from the last stage of the carrier rocket with a strictly imposed velocity. The separation took place practically without any perturbing effects upon the further motion of the last stage. Alongside with this, the construction of Electron I was worked out in such a way that the station was most compact without any protruding parts at time of separation.

WORKING PRINCIPLES AND APPARATUS

Electron I and Electron II are automatic scientific satellite stations conceived for a complex study of the circumterrestrial space.

Fig 2 and 3 offer a general view of Electron I and II. The solar batteries, antennas and guidance systems are located at the exterior of the spacecraft. The cylindic part of the body of the body of the spaceship has revolving jalousies as part of thermal regulation. The station Electron I has folding antennas and solar battery panels which open up on command as soon as Electron I has separated from the carrier rocket. This is coupled with the assurance of separation over the active portion of the flight.

On the station Electron II the panels of solar batteries are solidly fastened to the frame. Electron I and Electron II have a great number of instruments effecting measurements at numerous points of the orbit. The result of measurements are registered by a special airborne apparatus. Later, all the data gathered are broadcast to Earth. The control of the whole apparatus is reliably assured from the ground.

Let us analyze the major problems which Electron I and Electron II must solve. The main problem is the study of the inner and outer radiation belts of the Earth. For this purpose both stations have indentical apparatus, measuring electrons and protons of different energies. This type of measurements will permit to determine the composition of emissions in the radiation belts simultaneously at two points of the circumterrestrial space.

Electron I flies around the Earth at the altitude of approximately 7000 km. With the aid of Electron I the inner radiation b elt and part of the outer belt are studied. At the same time, Electron II cuts through the outer radiation belt, moving beyond through interplantary space where particles of the radiation belts are absent and the main form of emission consists of cosmic rays.

The presence of identical apparatus on both stations allows to determine the location of the radiation belts in space. This apparatus is recording the particles with very high energies; for example, electrons with 2 million eV, protons - with 30 million ev and protons - with energies of more than 50 KeV. Particles of lower energies cannot penetrate through the hermetically sealed container. For the registration of such particles the appartus has been installed at the exterior sufrace of the spacecraft. The detectors are shielded with screens of extremely fine matter;their thickness constitutes a few thousandths of a fraction of mm. Electrons with 30 KeV and protons with energies of more than one million eV can penetrate through such screens. For the registration of particles with smaller energy,Electron II has been provided with the so-called spherical analyzer. No barrier of any kind stands in the path of particles hitting this analyzer. Being deflected in the electrostatic field, the particles flow along a circle. In flight, the electric voltage applied to the spherical analyzer is automatically switched off. By the same token, protons and electrons of various energies beginning with 10 eV are trapped. Low-energy particles can also be captured with the aid of a charged particle trap, similarly to the installation aboard

Soviet cosmic rockets having discovered the ionized geocorona and the outermost belt of the Earth consisting of comparatively low-energy electrons.

The multiple measurements in the geocorona and in the outermost belt with the aid of detectors designed for low-energy particles must significantly contribute to the volume of data on these regions of the circumterrestial space.

A radio transmitter "Mayak", emitting coherent radiowaves, is installed aboard Electron I. Observing these waves by means of ground stations one may track the propagation of radiowaves and determine the concentration of electrons at great heights. Low-energy particles are registered aboard Electron I by a special counter in conjunction with an accelerating tube. To shield the photomultiplier cathode from the light, the crystal must necessarily be covered up with some opaque material.

However thin the foil may be, it will at any rate oppose the ingress into the crystal of electrons with energies below 10 KeV. The accelerating tube, installed ahead of the crystal fills that gap, imparting to slow electrons a complementary velocity and bring their energy to 10 KeV. Thus the apparatus installed allows the registration of electrons with lowest energies (about 100 eV) up to several tens of thousands eV. The flow of charged particles within the Earth's radiation belt is dependent on the Earth magnetic field. Therefore, the information about the radiation belt must be compounded with the

data on the magnetic field. The flow of particles within the radiation belt can lead toward the creation of an additional magnetic field.

For the registration of the value, direction and intensity of the magnetic fields 2 magnetometers were placed on Electron 2. One of them being less sensitive, is capable of measuring a relative γ intense magnetic field. The other is designed for measuring weak magnetic fields which exist in the outer radiation belt and even at great destances beyond it. The concentration of charged particles of different energies inside the radiation belts and the value of the magnetic fields created by these particles are closely linked with one another. The simultaneous measurement of the various particles and different magnetic fields will provide a very important information about the Earth radiation belts. It is obvious that the investigations of the upper layers of the atmosphere are very important. In this article we wish to underline the possible relationship between the Earth radiation belts and the formation of the upper part of the atmosphere.

Particles of the Earth radiation belts "traveling" from North to South sometimes end their life below the areas containing the belts. Under the influence of some still unknown factors they are pouring out from the radiation belts, bombarding the higher layers of the atmosphere. In their way the radiation belts act upon the Earth's atmosphere. On the other hand it is possible that there appear in the upper layers of the atmosphere some of those particles which, upon acceleration and egress beyond the limits of the atmosphere become particles of the radiation belts. On both scientific stations Electron I and Electron II radio-

frequency mass speetrometers were installed for the determination of the chemical composition of the upper atmosphere layers. Aside from elementary particles (electron, protons) dust particles or the so-called micro-meteorites, move around the Earth. As was established with the aid of American and Russian satellites the number of the micro meteorites is greater inside the area nearest to Earth, than within the interplanetary space. The reason for this is very simple: In this area there are, besides the micrometeorites which are reaching here from the interplanetary space, micrometeorites that circle around the Earth for a long time.

A meteorite detector was installed on Electron I, with the aid of which we can register the number of strokes along the satellite's orbit. Also installed on Electron I is an apparatus for the registration of Sun's X rays. The intensive X-ray emission is appearing during solar flares. The registration of Sun's X rays will provide the possibility of determining the conditions of Sun's activity and their relationship with the Earth's radiation belts. Creation of the automatic space laboratories, flying deep inside the cosmic space, will provide an opportunity to study the emissions which have been reaching the Earth from cosmic space depths.

The majority of cosmic rays originate beyond our solar system. The Earth's atmosphere and magnetic field are a serious hindrance to cosmic rays on their way to the Earth. Electron II is traveling beyond the magnetic field of the Earth, and because of this all the apparatus for the registration of cosmic rays is concentrated in it. Some of this apparatus allowed not only the registration of cosmic ray intensity,

but also the determination of their chemical composition, i.e. ascertain the nuclei from the standpoint of what atoms they originate from and in what numbers. The opportunities of the contemparary astronomy are very big, because - besides the visual rays we can observe invisible radiowaves, arriving from space. A new science - radiostronomy has been developed, as we know that the Earth is surrounded by the ionosphere, which reflects the short, medium and long radiowaves. Because of this it is possible to communicate with different parts of Earth. This is a good advantage, but at the same time it bounces all the waves arriving from beyond space with wave length greater than 100 - 150 meters and back into space. Meantime these waves are valuable informations about the Universe. In order to register such waves one must come out of the Earth atmosphere and that is what satellites are doing. Electron I and Electron II carry radio receivers, able to register radiowaves of 200 - 400 meter wavelengths. These doubtless will contribute a very valuable scientific information.

More than a month has passed since the successful launching of Electron I and II. On March 12, Electron I completed 357 convolutions and 155 radio communication sessions have been carried out.

Electron II completed more than 44 revolutions with 25 such sessions.

All the data from that month correspond to the period of the Quiet Sun. Further research will allow the study of time variations of space characteristics for various levels of solar activity.

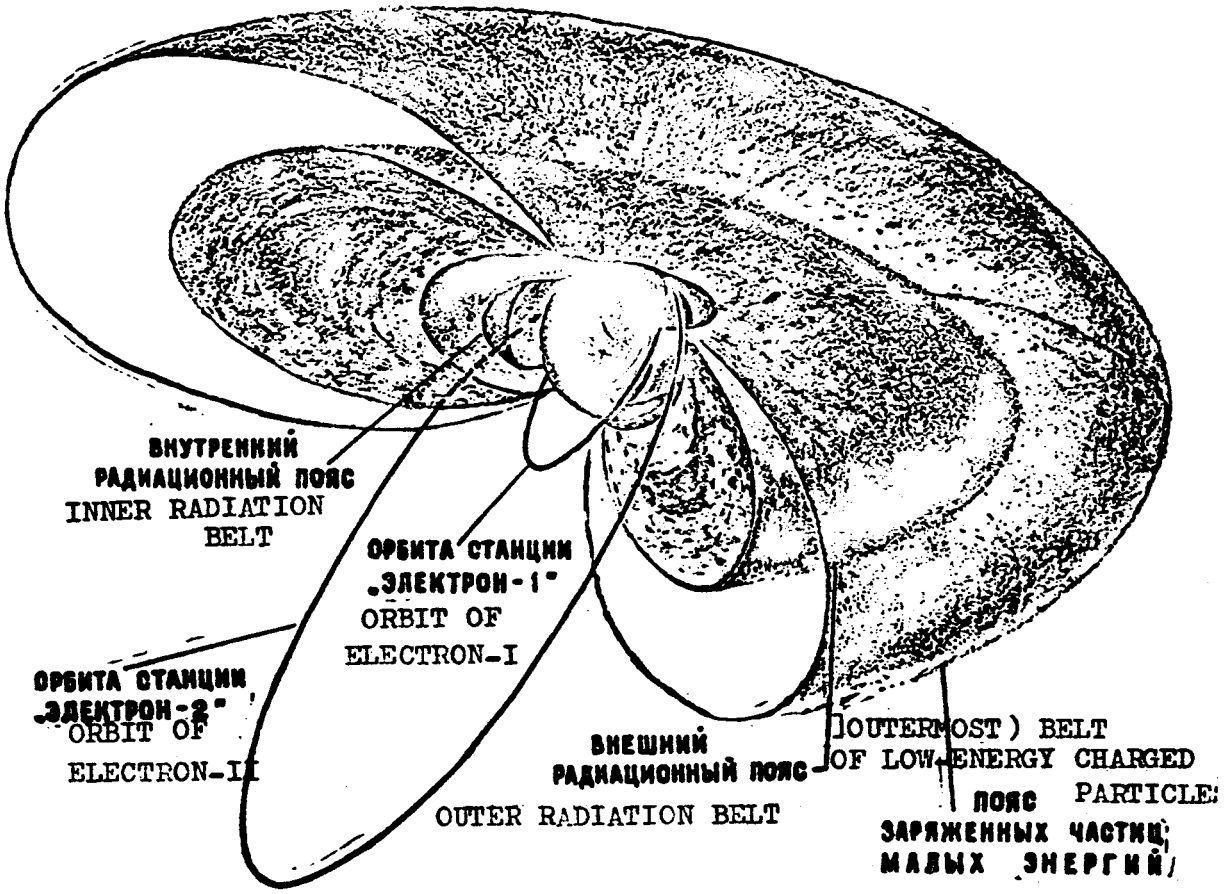

Рис. 1. СХЕМЫ ОРБИТ СПУТНИКОВ «ЭЛЕКТРОН-1» И «ЭЛЕКТРОН-2».

FIG.1 - GENERAL SCHEME SHOWING THE ORBITS OF SATELLITES "ELECTRON-I" and "ELECTRON-II" AND THEIR POSITION WITH RESPECT TO RADIATION BELTS.

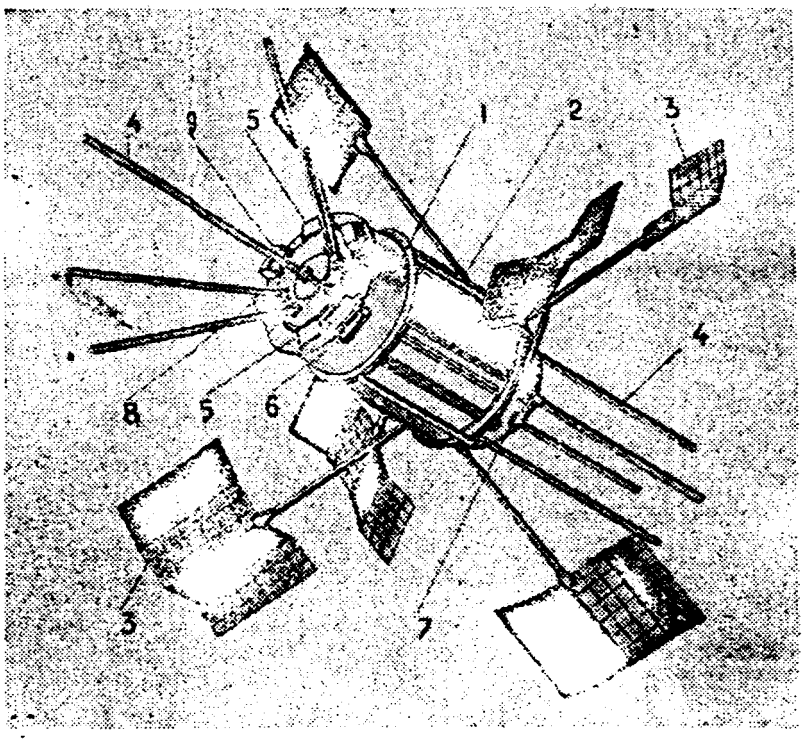

Рис. 2. КОСМИЧЕСКАЯ СТАНЦИЯ «ЭЛЕКТРОН-1»: 1 — герметичный корпус станции; 2 — жалюзи системы терморегулирования; 3 — солнечные батареи; 4 — антенны; 5 — детектор микрометеоритов; 6 — прибор для регистрации корпускулярного излучения; 7 — масспектрометр; 8 — детектор протонов; 9 — прибор для изучения энергетического спектра электронов радиационных поясов.

Fig. 2. - General View of the Station "Electron-I"

1.- hermetically-sealed body; 2- jalousied of the thermo-regulating system; solar batteries; 4.- antennas; 5- micrometeorite detector; 6.- device for the registration of corpuscular radiation; 7.- mass-spectrometer; 8.- detector of protons; 9.- device for studying the energy spectrum of radiation belts' electrons.

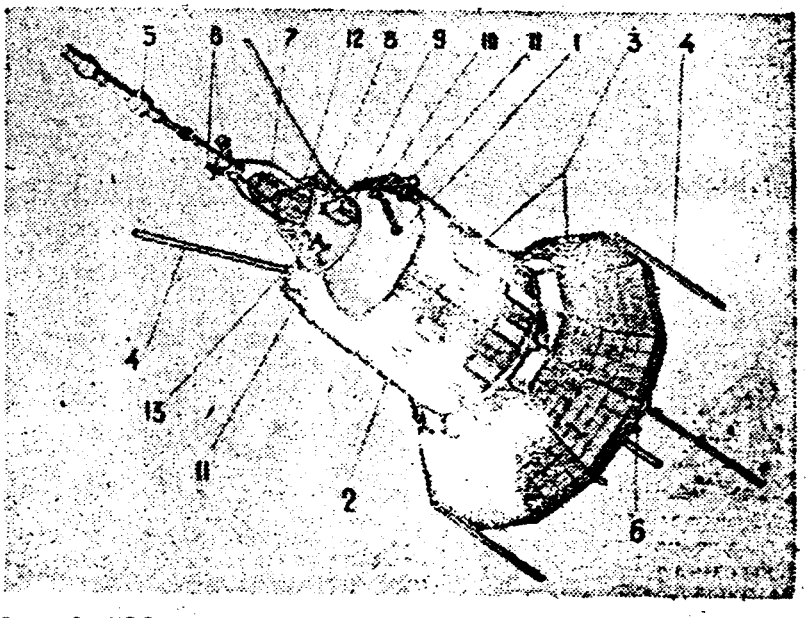

Рис. 3. КОСМИЧЕСКАЯ СТАНЦИЯ «ЭЛЕКТРОН-2»: 1 — герметичный корпус станции; 2 — жалюзи системы терморегулирования; 3 — солнечные батареи; 4 — антенны; 5 — магнитометр; 6 — датчики солнечной ориентации; 7 — сферический анализатор для изучения энергетического спектра частиц малой энергии; 8 — прибор для изучения химического состава космических лучей; 9 — прибор для изучения энергетического спектра электронов радиационных поясов; 10 — масспектрометр; 11 — прибор для исследования рентгеновского излучения Солнца; 12 — детектор протонов малых энергий; 13 — ловушки заряженных частиц.

Fig. 3.- SPACE STATION "ELECTRON-2".-

1- hermetically-sealed body (frame);
2- jalousies of the thermoregulatory system;
3.- solar batteries; 4.- antennas; 5.- magnetometer; 6.- solar orientation sensors;
7.- spherical analyzer for the study of the energy spectrum of low-energy particles;
8.- device for the study of the chemical composition of cosmic rays; 9.- device for studying the energy spectrum of radiation belts' electrons
10.- mass-spectrometer; 11.- device for the investigation of Sun's X-ray radiation; 12- detector for low-energy protons; 13.- charged particle traps.

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